UCRL-JC-125870 Sum

SUMMARY OF THE FINDINGS OF THE APAC SPILLS WORKING GROUP

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The Spills Working Group was one of six working groups established under the DOE-DP Accident Phenomenology and Consequence (APAC) methodology evaluation program. The objectives of APAC were to assess methodologies available in the accident phenomenology and consequence analysis area, evaluate their adequacy for purposes of accident analysis at DOE facilities, identify development needs, and define standard practices to be followed in the analyses supporting facility safety basis documentation. The Spills Working Group focused on methodologies for estimating four types of spill source terms: liquid chemical spills and evaporation, pressurized liquid/gas releases, solid spills and resuspension/sublimation, and resuspension of particulate matter from liquid spills.

The Spills Working Group first reviewed regulatory documents, standards, and guidance documents to identify requirements that the methodologies must meet. The requirements were developed into a set of review criteria for model evaluation. A set of publicly available computer models with capabilities for quantifying release rates or released amounts from spills of chemical or radiological materials was identified. Additionally, a set of sample test problems was established to evaluate the general applicability and suitability of a specific model to some common or probable accident release scenarios.

Code reviews allowed the working group to identify those models with appropriate and/or unique capabilities important for DOE safety analysis applications. After reviewing the code evaluations and the results of the test problem exercise, the working group agreed on a recommended set of computer codes. Some more detailed models were more applicable to scenarios at higher hazard facilities. The recommended models are identified in the table below, according to spill type and the facility hazard category to which they most reasonably apply.

Facility Hazard Category	Liquid Chemical Spills and Evaporation	Pressurized Liquid/Gas Releases	Solid Spills and Resuspension/ Sublimation	Resuspension of Material from Spilled Liquids
Low/ Category 3	TScreen ADAM ALOHA	TScreen ALOHA	HOTSPOT KBERT^{+}	HOTSPOT
Moderate/ Category 2	ADAM ALOHA CASRAM HGSystem	ALOHA CASRAM HGSystem	HOTSPOT KBERT^{+}	HOTSPOT
High/ Category 1	CASRAM HGSystem	CASRAM HGSystem	HOTSPOT KBERT^{+}	HOTSPOT

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-ENG-48.

[+]KBERT is still under development and was therefore not fully evaluated. It was included here because of its unique capabilities and the widespread use of the handbook[1], on which it is based.

The test problem exercise was performed with the goal of testing the capabilities of the codes. Some previously established problems applying to liquid chemical spills and evaporation and pressurized liquid/gas releases were adopted for the exercise. The code results for a given problem varied by up to an order of magnitude. This was primarily attributed to the differences in how the models treated the physics and thermodynamics of the problems.

In general, hand calculations are acceptable, but they typically may only be practical for simple problems. When analysis requires the use of formulations that can readily be done by hand, this approach is recommended. Hand calculations may be particularly useful for problems like resuspension, where only a limited number of codes are available. Additionally, Reference 1 was identified as an excellent source of information for estimating source terms by hand.

The Spills Working Group identified a set of good engineering or good safety analysis practices for use in preparation of safety analysis documentation:

(1) Chemical Lists: The group recommended consulting the following lists for assistance in identifying chemicals of greatest concern for analysis: (a) EPA list (40CFR68); (b) OSHA list (29CFR1910.119); (c) DOE-EH list of unique chemicals in the DOE complex[2]; (d) Sample list of hazardous chemicals within the DOE[3].

(2) Chemical Selection Criteria: If the analyst chooses to evaluate chemicals not on the lists noted above, EPA criteria noted below can be used as an additional basis for selection: (a) include chemicals with vapor pressure above 10 mm Hg (interpreted to be at 20 ^{o}C); (b) include chemicals in concentrations above 1 %wt.

(3) Default Parameter Values: Some specific guidance associated with pressurized liquid/gas release scenarios is provided. The details are given in the final report.

(4) Consult EPA Documents, where appropriate: An earlier methodology study that was performed for the EPA was identified[4]. This reference should be consulted when selecting parameter values.

(5) Parameter Selection: The analyst should be consistent in making realistic selection of parameters for a given final report.

(6) Caution for Cryogenic Releases: An instantaneous spill is not always the worst case. For example, when the boiling point of the material is significantly below ambient, an instantaneous release may result in freezing of the ground. This may change the ground thermal conductivity in such a fashion that the source term is not maximized.

Several areas for follow-on work were identified:

(1) It would be valuable to expand and conduct a more thorough search of models available, first in the U.S., and then internationally. This wider search for state-of-the-science models could include private sector codes if certain conditions are met pertaining to documentation and ultimately to licensing fees.

(2) A performance evaluation of evaporating pool models against as complete a data set as possible should be conducted. A search for spill and evaporation experimental data for comparison with predictions would be valuable. A comparison against measured data would provide insight on model performance.

(3) A more thorough review of the codes, including understanding why the sample problem results were different, would be beneficial. The review could include a sensitivity/uncertainty analysis.

(4) Some effort should be directed towards providing better guidance on selection of spill pool depth. The 1 cm depth commonly used appears to be arbitrary.

The Spills Working Group also identified and recommended areas for model improvement:

(1) Improved modeling is needed to handle flash fraction formation properly.

(2) Improvements in aerosol generation and entrainment modeling would be beneficial.

(3) A good model does not currently exist for liquid pool evaporation inside a facility.

(4) The capability to model water reactives would be valuable.

(5) Spills involving multi-components or chemical mixtures cannot currently be properly modeled. Consideration should also be given to potential chemical reactions that may occur subsequent to a spill.

(6) A code should be developed to specifically model solid sublimation.

(7) A better understanding of the resuspension process during the evaporation phase of a spilled liquid containing dissolved/suspended solid material would be beneficial.

(8) Any final validation of KBERT should be completed so that the code can further reviewed.

REFERENCES

1. U.S. Department of Energy, “Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities”, DOE-HDBK-3010-94, July 1994.
2. S.J. Brereton et al., “Draft of the Final Report of the Accident Phenomenology and Consequence (APAC) Methodology Evaluation Spills Working Group”, Lawrence Livermore National Laboratory, UCRL-ID-xxxxxx, September 1996.
3. U.S. Department of Energy, “Chemical Safety Vulnerability Working Group Report”, DOE/EH-0396P, September 1994.

4. U.S. Environmental Protection Agency, “Guidance on the Application of Refined Dispersion Models for Hazardous/Toxic Air Releases”, EPA-454/R-93-002, May 1993.